Diet transition and wellbeing: challenges and prospects for food systems

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TSE - INRA

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Food: a large budget share for consumers

Table: Food, Beverages and Tobacco budget share (2005)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Budget share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low-income</td>
<td>48.5</td>
</tr>
<tr>
<td>Middle-income</td>
<td>31.1</td>
</tr>
<tr>
<td>High-income</td>
<td>20.4</td>
</tr>
</tbody>
</table>

Source: Worldbank
Food: a large budget share for consumers

Annual income spent on food (% of household consumptive expenditures)  

A map of the world based on food costs as a percentage of income compared with incidence of juvenile malnutrition.

The size of the country represents the percentage spent on food. The darker the color, the higher the rate of malnutrition.
Road Map

- Where we are? Health, environment
- Why we are here? Income changes / Technological change
- What to do? Public intervention requested
- Research needs and new challenges
Diet an important risk factor for NCDs

Leading risks factor causes of DALYs

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>% DALYs</th>
<th>Risk factor</th>
<th>% DALYs</th>
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</thead>
<tbody>
<tr>
<td>Low-income countries</td>
<td></td>
<td>High-income countries</td>
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<tr>
<td>Childhood underweight</td>
<td>9.9</td>
<td>Tobacco use</td>
<td>10.7</td>
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<tr>
<td>Unsafe water, hygiene</td>
<td>6.3</td>
<td>Alcohol use</td>
<td>6.7</td>
</tr>
<tr>
<td>Unsafe sex</td>
<td>6.2</td>
<td>Overweight and obesity</td>
<td>6.5</td>
</tr>
<tr>
<td>Suboptimal breastfeeding</td>
<td>4.1</td>
<td>High blood pressure</td>
<td>6.1</td>
</tr>
<tr>
<td>Indoor smoke from fuels</td>
<td>4.0</td>
<td>High blood glucose</td>
<td>4.9</td>
</tr>
<tr>
<td>Vitamin A deficiency</td>
<td>2.4</td>
<td>Physical inactivity</td>
<td>4.1</td>
</tr>
<tr>
<td>High blood pressure</td>
<td>2.2</td>
<td>High cholesterol</td>
<td>3.4</td>
</tr>
<tr>
<td>Alcohol use</td>
<td>2.1</td>
<td>Illicit drugs</td>
<td>2.1</td>
</tr>
<tr>
<td>High blood glucose</td>
<td>1.9</td>
<td>Occupational risks</td>
<td>1.5</td>
</tr>
<tr>
<td>Zinc deficiency</td>
<td>1.7</td>
<td>Low F&amp;V intake</td>
<td>1.3</td>
</tr>
</tbody>
</table>

Source: WHO, 2009

Disability Adjusted Life Years (DALY) = Years Life Lost Disability (YLD) + Years of Life Lost (YLL)
DALY rate attributable to individual dietary risks in 2017 (undernutrition and obesity not included)

Age-standardized prevalence of obesity in adult women (BMI ≥ 30 kg/m²), 2014

Source: WHO Global status report on NCDs, 2014.

Fig. 7.2 Age-standardized prevalence of obesity in women aged 18 years and over (BMI ≥30 kg/m²), 2014

Prevalence of obesity (%)*

<table>
<thead>
<tr>
<th>Prevalence (%)</th>
<th>&lt;5</th>
<th>5–14.9</th>
<th>15–24.9</th>
<th>≥25</th>
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<tbody>
<tr>
<td>Data not available</td>
<td>Not applicable</td>
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</table>

* BMI ≥30 kg/m²

No country is experiencing a decrease in obesity rate
Increase in obesity rate

Diet as an important risk factor for NCDs

Priorities that might differ between countries / group of countries

Need to evaluate the health impacts of deficiency/excess of nutrients (food groups) intakes at a more detailed level

Large social inequalities wrt NCDs / Obesity (not shown)
Greenhouse gas emissions by sector

World Greenhouse gas emissions by sector

- **Transportation**: 13.5%
- **Electricity & Heat**: 24.8%
- **Other Fuel Combustion**: 9%
- **Industry**: 10.4%
- **Fugitive Emissions**: 3.9%
- **Industrial Processes**: 3.4%
- **Land Use Change**: 18.2%
- **Agriculture**: 13.5%
- **Waste**: 3.6%

**End Use/Activity**
- Road: 9.9%
- Air: 1.6%
- Rail, Ship: 2.3%
- & Other Transport: 2.3%
- Residential Buildings: 9.9%
- Commercial Buildings: 5.4%
- Unallocated: 3.5%
- Iron & Steel: 3.2%
- Aluminium/Non-Ferrous Metals: 1.4%
- Machinery: 1.7%
- Food & Tobacco: 1.1%
- Chemicals: 4.8%
- Cement: 3.8%
- Other Industry: 5.0%
- T&D Losses: 1.3%
- Coal Mining: 1.5%
- Oil/Gas Extraction, Refining & Processing: 6.3%
- Deforestation: 18.3%
- Afforestation: -1.5%
- Reforestation: -0.5%
- Harvest/Management: 2.5%
- Other: -0.6%
- Agricultural Energy Use: 1.4%
- Agriculture Soils: 6%
- Livestock & Manure: 5.1%
- Rice Cultivation: -1.5%
- Other Agriculture: 0.9%
- Landfills: 1.2%
- Wastewater, Other Waste: 1.2%

**Gas**
- Carbon Dioxide (CO₂): 77%
- Methane (CH₄): 14%
- Nitrous Oxide (N₂O): 8%

All data is for 2000. All calculations are based on CO₂ equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 41 755 MtCO₂ equivalent. Land use change includes both emissions and absorptions. Dotted lines represent flows of less than 0.1 percent of total GHG emissions.

GHG emissions of the food chain

- Food chain: 15 to 30% of GHG emissions of the EU member states. Most at the agricultural level (50 to 60%), mainly N₂O (soils, livestock), and CH₄ (ruminants).

- Agricultural sector: 10% of EU GHG emissions.
  - Animal production: 5% (direct) + part of 5% from crop production
  - Animal production including feed imports and ILUC: > 80% of EU emissions from agriculture

- Issues:
  - LCA versus accounting methods
  - Time horizon (N₂O and CH₄ equivalent in CO₂)
Greenhouse gas emissions: focus on protein sources

<table>
<thead>
<tr>
<th>Protein Source</th>
<th>GHG Emissions (kg CO₂eq)</th>
<th>Land Use (m²·year)</th>
<th>Acid. (g SO₂eq)</th>
<th>Eutroph. (g PO₄³⁻eq)</th>
<th>Scty. Water (kL eq)</th>
</tr>
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<tr>
<td>Beef (beef herd) 724</td>
<td>20 50</td>
<td>42 164</td>
<td>0.4 2.0</td>
<td>4.4 41</td>
<td>50</td>
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<tr>
<td>Lamb &amp; Mutton 757</td>
<td>12 20</td>
<td>30 185</td>
<td>4.8 11</td>
<td>4.3 11</td>
<td>50</td>
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<tr>
<td>Beef (dairy herd) 490</td>
<td>9.1 17</td>
<td>7.3 22</td>
<td>0.4 3.7</td>
<td>0.3 1.2</td>
<td>50</td>
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<tr>
<td>Crustaceans (farmed) 1.0k</td>
<td>5.4 18</td>
<td>0.4 2.0</td>
<td>4.4 41</td>
<td>4.3 11</td>
<td>50</td>
</tr>
<tr>
<td>Cheese 1.9k</td>
<td>5.1 11</td>
<td>4.4 41</td>
<td>4.8 11</td>
<td>4.3 11</td>
<td>50</td>
</tr>
<tr>
<td>Pig Meat 116</td>
<td>4.6 7.6</td>
<td>4.8 11</td>
<td>0.4 3.7</td>
<td>0.3 1.2</td>
<td>50</td>
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<tr>
<td>Fish (farmed) 612</td>
<td>2.5 6.0</td>
<td>0.4 3.7</td>
<td>4.4 41</td>
<td>4.3 11</td>
<td>50</td>
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<tr>
<td>Poultry Meat 326</td>
<td>2.4 5.7</td>
<td>3.8 7.1</td>
<td>4.8 11</td>
<td>4.3 11</td>
<td>50</td>
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<tr>
<td>Eggs 100</td>
<td>2.6 4.2</td>
<td>4.0 5.7</td>
<td>0.4 3.7</td>
<td>0.3 1.2</td>
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<tr>
<td>Tofu 354</td>
<td>1.0 2.0</td>
<td>1.1 2.2</td>
<td>4.4 41</td>
<td>4.3 11</td>
<td>50</td>
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<tr>
<td>Groundnuts 100</td>
<td>0.6 1.2</td>
<td>1.8 3.5</td>
<td>4.4 41</td>
<td>4.3 11</td>
<td>50</td>
</tr>
<tr>
<td>Other Pulses 115</td>
<td>0.5 0.8</td>
<td>4.6 7.3</td>
<td>4.8 11</td>
<td>4.3 11</td>
<td>50</td>
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<tr>
<td>Peas 438</td>
<td>0.3 0.4</td>
<td>1.2 3.4</td>
<td>4.4 41</td>
<td>4.3 11</td>
<td>50</td>
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<tr>
<td>Nuts 199</td>
<td>-2.2 0.3</td>
<td>2.7 7.9</td>
<td>4.8 11</td>
<td>4.3 11</td>
<td>50</td>
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<tr>
<td>Grains 23k</td>
<td>1.0 2.7</td>
<td>1.7 4.6</td>
<td>4.8 11</td>
<td>4.3 11</td>
<td>50</td>
</tr>
</tbody>
</table>

Source: Poore and Nemecek, 2018.
Greenhouse gas emissions from animals in the EU

From feed production. These data clearly show that the principal sector to target for climate change mitigation is ruminants, especially cattle and including both beef and dairy cows. Emissions per kg of meat differ greatly between the species. Ruminants have the largest emissions with commonly reported values of 20-30 kg CO$_2$e per kg of beef and 9-28 kg CO$_2$e per kg of sheep and goat meat. Pigmeat has lower emissions, 5-10 kg CO$_2$e per kg of meat, and poultry the lowest figures, 5-7 kg CO$_2$e per kg (Leip et al., 2010; Weiss and Leip, 2012; Winkler and Winiwarter, 2015). These ranges for each species are wide, and even larger variations can be found in specific production systems in different countries: 14.2 kg CO$_2$e/kg beef in Austria compared to 44.1 CO$_2$e/kg beef in Cyprus. Such differences can be explained in the quite different performance levels of production in different systems (McAuliffe et al., 2018) and in the length of the grass growing season. Emission rates per kg of dairy products are also complicated by the inclusion (or not) of the beef and veal which are co-products from the dairy herd. However, the general conclusion is that systems which are most productive, as measured in the conventional sense of faster live weight gain, higher feed conversion efficiency, highest milk yields per cow, or eggs per bird will have the lower emissions per unit of product. These differences in emissions according to production efficiency provide the evidence that total emissions could be greatly reduced if efficiency were levelled up to the best performers. However, this in turn illustrates the complexity of the challenge because greater production intensity may be associated with deterioration of other environmental indicators, e.g. nutrient leakage, and may be accompanied by animal welfare concerns. Adding the public goods, e.g. cultural ecosystem services associated with livestock and their pastures, further complicates the assessment of these seemingly clear indicators.

Greenhouse gas accounting and measurement methods are still evolving, and there is no doubt that the fluxes of GHG are more complex in agriculture and land use than in other sectors. It is often claimed that livestock grazing systems offer a beneficial climate contribution through C capture. The argument is that ruminants feeding solely on grass can only emit as much carbon as they obtain from the grass itself. And since the grass captures atmospheric carbon to grow, ideally this would be a system in equilibrium. However, carbon sequestration rates by pastures are highly site specific and depend on numerous factors (type of plants, grazing intensity, climate, fertilization, fungus and bacteria dominance). In general, there is scope for grasslands to be managed more effectively to increase C capture, but it is neither simple nor easily verified. Despite a large interest in finding a generalized value for C sequestration to include in budgets we are very far from achieving this. In its estimates, the IPCC assumes that after 20 years grasslands stop accumulating carbon (Smith, 2014). Therefore, soils eventually become saturated in Figure 5.

**Figure 5.** Total GHG emissions from livestock in the EU27 for the period 2003-2005 using the MITERRA-Europe model (adapted from Lesschen et al., 2011)

Meat production: Pig = 50%, poultry = 30%, and Beef = 20%
Meat consumption: trends

This chapter brings together the key data on the EU consumption and production of livestock products with an overview on the beneficial and negative effects of livestock on the environment and human health. The focus of this study is the EU so the scale and importance of livestock in the EU and its share of world trade in livestock and feed are juxtaposed against the global data where possible.

2.1.1. EU livestock consumption

Meat consumption. FAO statistics show EU citizens are supplied annually with an average of 81 kg of meat per capita per year of carcass weight, that correspond to approximately 51 kg/capita/yr of meat consumption. This is twice the global average and makes the EU one of the FAostat data 'Food supply: Livestock and Fish Primary Equivalent' for 2013. After excluding waste and parts of animals not eaten (see Chapter 3 for more information).

Figure 1. A) Total meat consumption, for selected world regions between 1961-2012; B) Per capita consumption, same regions between 1961-2012 (data source: own figure, data from FAOSTAT)

Other environmental impacts

- Water pollution
- Air pollution
- Impact on biodiversity

Figure 6. Nitrogen surplus in kg per hectare of agricultural land in the EU27 in 2005 (Source: EEA, 2010)
Large environmental impacts of the food chain

Diet composition matters: share of animal products (and type of animal products) in the diet ('quantity' effect)

Production techniques also matter ('intensity' (per-unit) effect)

Increase in meat consumption as a global threat for the environment

Inter-related issues as changes in the environment (climatic change for example) also affect human health
Why we are here?
Role of incomes and technological change

Ajustements semi-log sur 163 pays

Source : P. Combris, P. Martin d'après FAO Stat
1. Evolution de la consommation alimentaire dans le monde depuis 50 ans
1.2. Calories animales, calories végétales
• L'augmentation du niveau et de la part des calories d'origine animale dans la ration alimentaire est une caractéristique majeure de la transition nutritionnelle. C'est une tendance de long terme.
• La généralisation progressive de cette tendance à l'ensemble de la population du monde va se heurter aux limites des ressources disponibles.
• D'après l'étude prospective Agrimonde, l'agriculture pourra nourrir 9 milliards d'individus en 2050, avec une ration calorique moyenne de l'ordre de 3000 kcal/personne/jour, à condition que la consommation des produits d'origine animale ne dépasse pas 500 kcal par personne et par jour. Le seuil des 500 kcal d'origine animale vient d'être atteint en moyenne dans le monde. Les pays en transition se dirigent vers une consommation de 1000 kcal d'origine animale.

Questions :
─ mécanismes sensoriels et physiologiques du goût pour les produits animaux
─ anticiper l’approche des limites
─ identifier des tendances inverses

Source : Périssé, Sizaret, François, FAO
Structure de la ration alimentaire en fonction du PIB (1960-1963)
Diet transition and income: Sum-up

- Last fifty years: same relationships between nutritional characteristics of diets and income
  - increase in animal products consumption
  - increase in fat intakes (free fat and animal fats)
  - increase in simple carbohydrates intakes
  - decrease in complex carbohydrates intakes

- Most of the world population is still at the beginning of the nutritional transition

- Global threat for the environment
Obesity as a consequence of technological change

**Weight = Balance between calories In and calories Out**

Growth in obesity as a function of technological change
Philipson and Posner (1999); Lakdawalla et al. (2005); Lakdawalla and Philipson (2009).

**Technological change has**

- Lowered the cost of consuming calories: lower real price of food
- Raised the cost of expanding calories: less physical expenditure of calories per hour worked
Why an increase in obesity? A simplified model

- Standard microeconomic model of the consumer
  - Weight function $W(F, S)$ (food intake ($F$) and calories expenditures ($S$))
  - Ideal Body weight: Utility is $U(W(F, S), F, C)$ **Utility is non-monotonic in weight (Inverted U-shape).**
- Consumer maximises utility under a budget constraint ($C + pF \leq I$)
- FOC is thus $U_W W_F + U_F = p U_C$
  - A decrease in the price of calories has a positive effect of weight
  - Beyond some weight, the utility loss from gaining weight is larger than the 'joy to eating'.
  - **If marginal dis-utility of weight gain is higher for larger incomes then we get an Inverted U-shaped weight income profile**
  - If true, richer people are less obese
Implications of the model

- **Obesity as a side effect** of 'welfare-improving' technological change
- Difficulty of improving welfare by rolling back obesity to earlier levels
Are these changes still welfare improving?

- Technological change also generates large 'externalities' (water pollution, pesticide residues, GHG, health related, ...)

**IS IT STILL WELFARE IMPROVING?**
- Social cost of obesity, France: €20 Billion 2016 as compared to €150 billion expenditures
- External costs of food in UK as high as food expenditures (Fitzpatrick and Young, 2017)
- Social cost of GHG: 700 Mt CO2eq/ year in the EU. €50 - €100 /t
- Cost burden of endocrine disrupting chemicals: controversies (Trasande, 2015; Bond and Dietrich, 2017)
Huge changes in food supply chain is well documented (e.g. Reardon for developing countries): from unprocessed fresh products to packaged and processed ready-to-eat or ready-to-heat

Evidence of 'hedonic over-eating’ when brain reward system overrides the metabolic signals (cf. Yu et al, 2015)

Food choices might be linked to a change in the food environment that has modified preferences

Only few studies on the causal effects
- Cockx et al. 2017: The growth of unhealthy food consumption with urbanization is largely linked to rising incomes rather than to urbanization per se.
- Dubois, Griffith, Nevo 2014. The food 'environment’ plays a significant role.
- Alcott et al., 2019. Preferences as the main explanation of differences in diet quality between income quartiles
Changes in income as a major source of diet transition. Still at the beginning of the process

Numerous analysis on the changes of diet / the impact of changes but lack of analysis of causal effects

Obesity, low quality diets as a side effect of technological change in the food chain

Interlink between food environment / preferences / income changes

Are these changes still welfare improving given the high external costs?

Some sort of equilibrium with a large number of external costs: How to move from this equilibrium?
What to do?
Public intervention requested
What to do?

- Changes in consumer demand: more local food, less processed, less additives, increased demand for organic products,

- Local initiatives from producers: direct sales including internet 'platforms', local brands, ....

- Actions that might remain marginal and will not change the core of the market

- Many market failures requesting public intervention
Why intervention is needed?

- **Health**: Evidence of association between diet and incidence of non-communicable diseases
  - Associated health care costs that are borne by taxpayers (internalities)
  - Delayed impact and difficulty to have the ‘correct’ knowledge.
    - Rationality bias. Room for paternalistic policies (Donoghue and Rabin, 2006; Cremer et al., 2012)
  - Difficulties to monitor nutrient intake (Griffith et al., 2010); Self control problem in managing food intake

- **Health**: pesticides, additives

- **Environment**: mainly externalities that need to be corrected

- **Emerging issue**: impact of the environment on health (does not change the need for intervention but might change the level needed)
How to intervene

Will be developed by Daniele Moro

- Instruments regulating how to produce .... focus on one 'goal'

- Instruments whose aims is to modify diets will impact multiple dimensions ... Convergence/ Divergence

- A key issue which is overlooked : How firms react to policies
(Will be developed by Jennie mc Diarmid. Some key results from an economic perspective).

- Tax based on GHG content (Carbon tax) might have **negative health impact** (favors energy dense products).
- To have positive impacts on both dimension (GHG / Health) tax design should integrate elements from nutrition.
- **Taxing products with high GHG content / Subsidizing F and V** Springmann et al. 2016; Doro and Réquillart 2018.
- **Convergence** between climate change and health goals is possible but not granted.
- For a given policy, convergence in some countries / divergence in some others (Irz et al, 2019).
- In Cost Benefit Analysis, **health impacts are likely to dominate GHG (and acidification) impacts.**
Why integrating firms reactions to policy is a key issue

- Price response to a tax policy
  - Soda tax in France. Pass through depends on the design of the tax (Bonnet and Réquillart, 2013)
  - Ad valorem: about 0.7; ignoring the price effect leads to **overestimating** the impact by 30%
  - Excise tax: about 1.2; ignoring the price transmission leads **underestimating** the impact by 20%

- Price response to a labeling policy
  - Dairy desserts market. Extending a mandatory label on the fat content (Allais et al., 2015)
  - Taking into account price response of firms **lowers** the potential impact of the policy (by 1/3).

- Price response to a ban on advertising
  - Potato chips market. Banning advertising on this market (Dubois et al., 2018)
  - Taking into account price response of firms **lowers** the potential impact of the policy (by 1/3).
Research needs / Challenges

- Assessing the multiple impacts of various regulations
- Focusing on intra-categories changes
- Lifestock sector issue
- Ultra Processed Food
Assessing the multiple impacts of various regulations

- n dimensions: Health, GHG, Land use, environment,
  - Linking models (economics, environment, epidemiology)
  - Develop consistent database

- What are the welfare impacts? Cost benefit Analysis

- Economics: Supply and demand response (frequently only demand)

- Limits (economic models):
  - Focus on inter-categories (small number of food items; potential effect is 'large' but changes are 'difficult')
  - Address heterogeneity of situations
  - Poor representation of processing / retailing activities
Focusing on intra-categories changes

- Intra-categories changes are easier but smaller impact ’per-unit’.
- More detailed models integrating firms strategy (empirical IO models)
- Better representation of consumer choices

Limits:
- Focus on at home consumption whereas out of home consumption is rising
- Focus on given group(s) of products: rest of the diet remains constant.
- How to integrate intra-categories changes in a larger framework (inter-categories changes)
Lifestock sector issue

- Lifestock sector: outside of durability boundaries (in particular GHG but also nutrients flows, ..)
- An interesting attempt: Safe Operating Space (RISE report, 2018)
- How to 'organize' the transition. Is the wine sector an interesting example? Lower quantity / Higher quality

![Diagram showing Safe Operating Space for EU livestock](Note: this figure's purpose is to illustrate the SOS concept, it's not data based)
Ultra Processed Food

- Emerging evidence on a possible adverse effect on health
  - Correlation with obesity at the country level (Monteiro et al. 2013, see also Popkin, 2017)
  - Recent study, more than 100,000 consumers. Correlation obesity, some NCDs, (Touvier et al., 2019)
  - Lot of uncertainty: rough classification, what explains the correlation (energy density, additives, processing, ...)

- Might significantly impact the demand and as a consequence the whole food chain

- What are the alternatives?
  - Going back to the kitchen ??
  - Make it healthier, new recipes, .. ?

- Need to better understand how consumers preferences evolve and how consumers adopt (or not) innovations
Thank you!
for your attention
Additional slides
Figure to illustrate Lakdawalla model
Table from Dubois et al. Graph from Alcott et al.
Figure 1: Ideal, Optimal, and Maximum Weight
Understanding the role of the environment and preferences to explain food purchases differences

- Dubois, Griffith, Nevo, AER, 2014.
- Structural demand model of food purchases estimated with individual data in three countries
- Counterfactual exercise to explain differences in purchases due to the environment and preferences

<table>
<thead>
<tr>
<th>Env / Pref</th>
<th>American in Paris</th>
<th>American in London</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prices Env</td>
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</tr>
<tr>
<td>Attributes Env</td>
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<tr>
<td>Nutrient Pref</td>
<td>$\approx 0$</td>
<td>$&lt; 0$</td>
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</table>

- Environment (prices, attributes) plays a significant role
- Interaction between preferences, prices and attributes explains cross-country differences
Figure 8: Correlation of Price Instrument with Product Health Index: Differential between High and Low Income Counties

Notes: This figure presents a binned scatterplot of Equation (17), showing the relationship between our price instrument and the interaction between product group Health Index and an indicator for whether the county average income in 2010 is above the national median, residual of product group and county fixed effects. Data are at the product group-by-county-by-year level. The estimated slope of the regression plotted is -0.0000639, with a standard error of 0.0000553.

Figure 9: Predicted Health Index for Each Income Group

Notes: Each category on the x-axis represents a separate counterfactual calculation. Income groups are quartiles of income, residual of household size and age and year indicators. The base category measures the Health Index for each income group when each group retains their own preferences and face their own local supply conditions. The second category sets all prices to those observed for the high-income group. The third category sets all prices and product nutrient characteristics to those in the high-income group. The fourth and fifth categories, respectively, set nutrient preferences and product group preferences equal to those for the high-income group. The Health Index presented on the y-axis is re-normalized so that the base difference between the highest- and lowest-income groups equals one.